Anderson Mulholland & Associates
ENVIRONMENTAL CONSULTANTS

Memorandum

Subject: Biopile Shut down Respiration Test

Date: May 8, 2013

Anderson, Mulholland and Associates, Inc. (AMAI) completed a shut down respiration test at the biopile at the BMS facility in Humacao according to the guidelines in the Building 5 Interim Corrective Measure Work Plan (Area E), dated May 2012 and the Temporary Unit Operations and Maintenance Plan dated May 2012. This is the fifth phase of soil excavation at the Building 5 Area. The shut down respiration test was performed between April 2 and 3, 2013. Details of the equipment used and the layout of the monitoring probes are also included in the Temporary Unit Operations and Maintenance Plan dated May 2012.

Prior to the respiration test, excavation and piling of material was completed on March 2, 2013. Soil gas monitoring probes were installed in the biopile between March 4 and 6, 2013. Blowers were switched on by March 19, 2013 and initial balancing of air flow was completed on March 25, 2013.

The objectives of this memo are to give a brief background on the purpose of the test, to provide a summary of the activities performed during the test and to present the results of the monitored gas concentrations.

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Respiration Test Objectives

The objectives of the respiration test were as follows:

- To give a clear indication by the change in measured gas values that an active aerobic microbe population is present in the biopile.
- To gather data to assess biopile performance.

The principle of the shut down respiration test is that the aerobic microbes that degrade hydrocarbons in the biopile consume oxygen and produce carbon dioxide. The oxygen is provided by the air from the blower. With the blower switched on oxygen is continually being replenished and measured oxygen should be close to its atmospheric level (21%) ranging from 15 to 20 % and measured carbon dioxide will be less than 5%.

However for clear evidence that biodegradation is occurring the blower is switched off for up to 48 hours. During this period both oxygen and carbon dioxide are measured. If the aerobic microbe population is healthy, without replenishment of air the measured oxygen level is expected to drop and the carbon dioxide level to increase. The rate at which the oxygen decreases gives an indication of the rate at which the hydrocarbons are being broken down.

Shut Down Respiration Test Activities

Initial gas readings were taken from the monitoring probes on April 2 between 8:00 AM and 8:15 AM prior to switching off the blower at 8:17 AM. Further readings were then taken at approximately two hours apart up to 8 hours after switching off the blower. Two further readings were then taken on April 3 at 24 and 31 hours after switching off the blower. At 31 hours oxygen levels at most probes were no longer decreasing and the test was stopped. The blower was switched back on at 16:00 on April 3. Gas readings were not taken from three of the probes (SG-6, SG-8, and SG-11) due to water in the lines.

Results

Tables showing the data for oxygen and carbon dioxide measurements are attached (Tables 1 and 2). A graph showing the average of monitoring probes is attached (Figure 1). Graphs are also attached showing the measured oxygen and carbon dioxide values taken from nine of the twelve monitoring probes during the test.

When the blowers are turned off, the soil gas probes provide a description of the behavior of the soil in the direct vicinity of the probes.

Oxygen values for four probes showed a decreasing trend from an initial range of 16.0 to 19.6% prior to shutdown to a final range of 4.3 to 10.6 %. Correspondingly, carbon dioxide values increased from a range of 0.7 to 3.3 % prior to shutdown to a range of 5.4 to 8.2 %. These results are an indication of an active microbe population.

At probes SG-1, SG-2, SG-10 initial oxygen values were high and did not significantly decrease during the test. Corresponding carbon dioxide values were low and did not significantly increase during the test. This may be due to the high soil porosity in the region of the probes that allowed the flow of air through soil. SG-4 and SG-10 were most likely plugged as the readings obtained from these probes did not change significantly over the course of the test.

The readings at most probes at elapsed time 31 hours did not show any further significant decrease in oxygen. Therefore, during this test oxygen limiting conditions for aerobic microbe activity were reached some time between 24 and 31 hours after the blower was switched off.

The amount of oxygen consumption and carbon dioxide production occurring around a majority of the soil gas probes suggest that significant biodegradation is occurring in the biopile. The average behavior of the oxygen consumption and carbon dioxide production in the probes meet expectations with respect to apparent biodegradation and biopile performance. The respiration test demonstrates that there is significant biological activity in the biopile.

Table 1

Shutdown Respiration Test
Oxygen Results

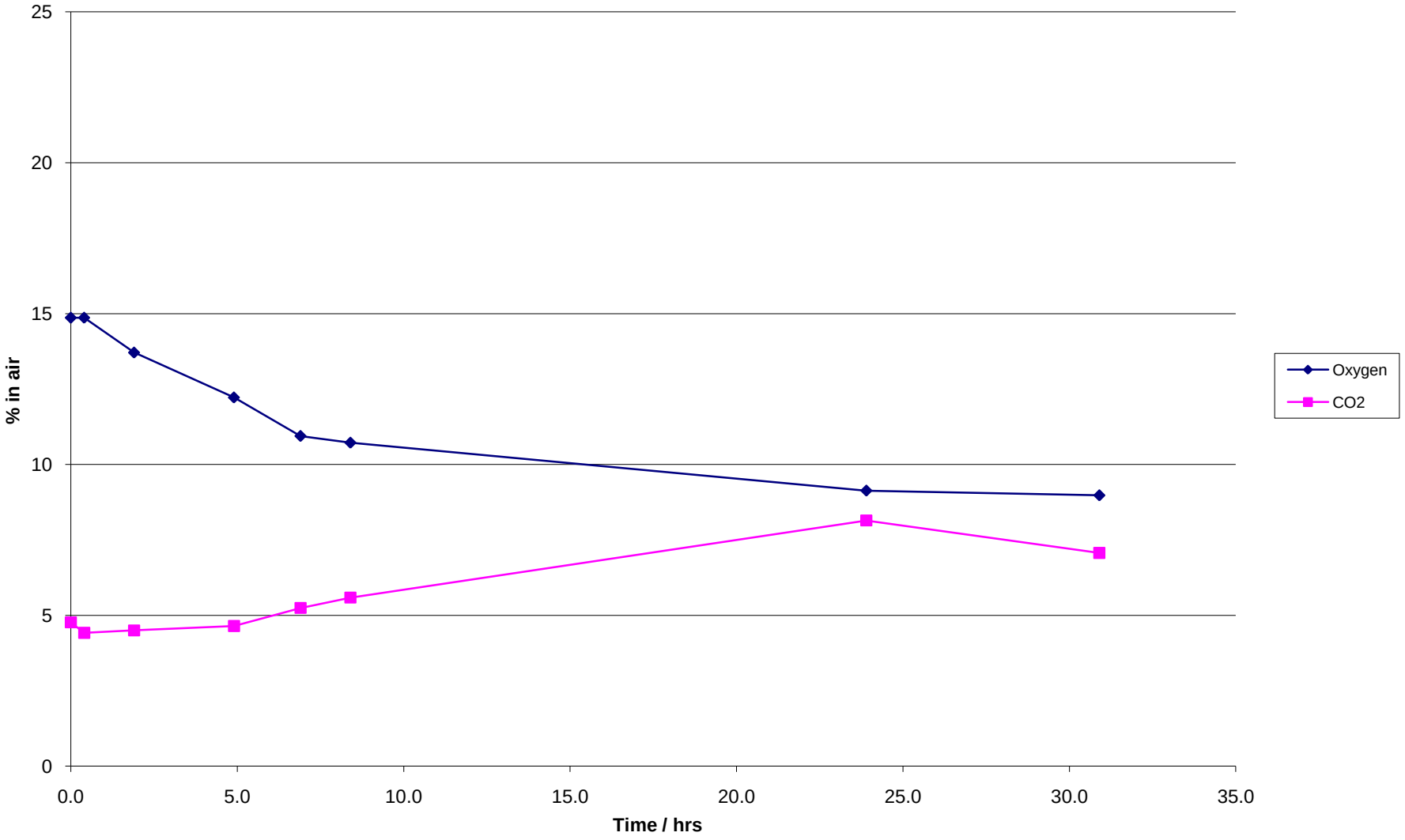
Soil Gas Probe	Baseline (% O2)	Hour 0.5 (% O2)	Hour 2 (% O2)	Hour 5 (% O2)	Hour 7 (% O2)	Hour 8 (% O2)	Hour 24 (% O2)	Hour 31 (% O2)
SG-1	17.8	16.1	16.9	16.2	14	13.6	14.1	13.5
SG-2	18.8	19.2	19	19.4	18.8	19.6	19.8	18.4
SG-3	19.6	18.8	16.3	11.7	10.4	10	4.3	9.3
SG-4	1.6	1.5	1	1	1.2	0.8	0.6	1.1
SG-5	17.4	16.4	14.3	11.2	9.6	9	6.5	6.8
SG-6								
SG-7	16	16.4	14.3	9.8	8.8	8.8	7	0.3
SG-8								
SG-9	6.7	9.4	11.2	9.7	8.2	7.3	0.5	0.5
SG-10	17.5	18.4	15.8	19.7	15.7	16.4	18.8	18.8
SG-11								
SG-12	18.4	17.6	14.6	11.3	11.8	11	10.6	12.1
AVG	14.9	14.9	13.7	12.2	10.9	10.7	9.1	9.0

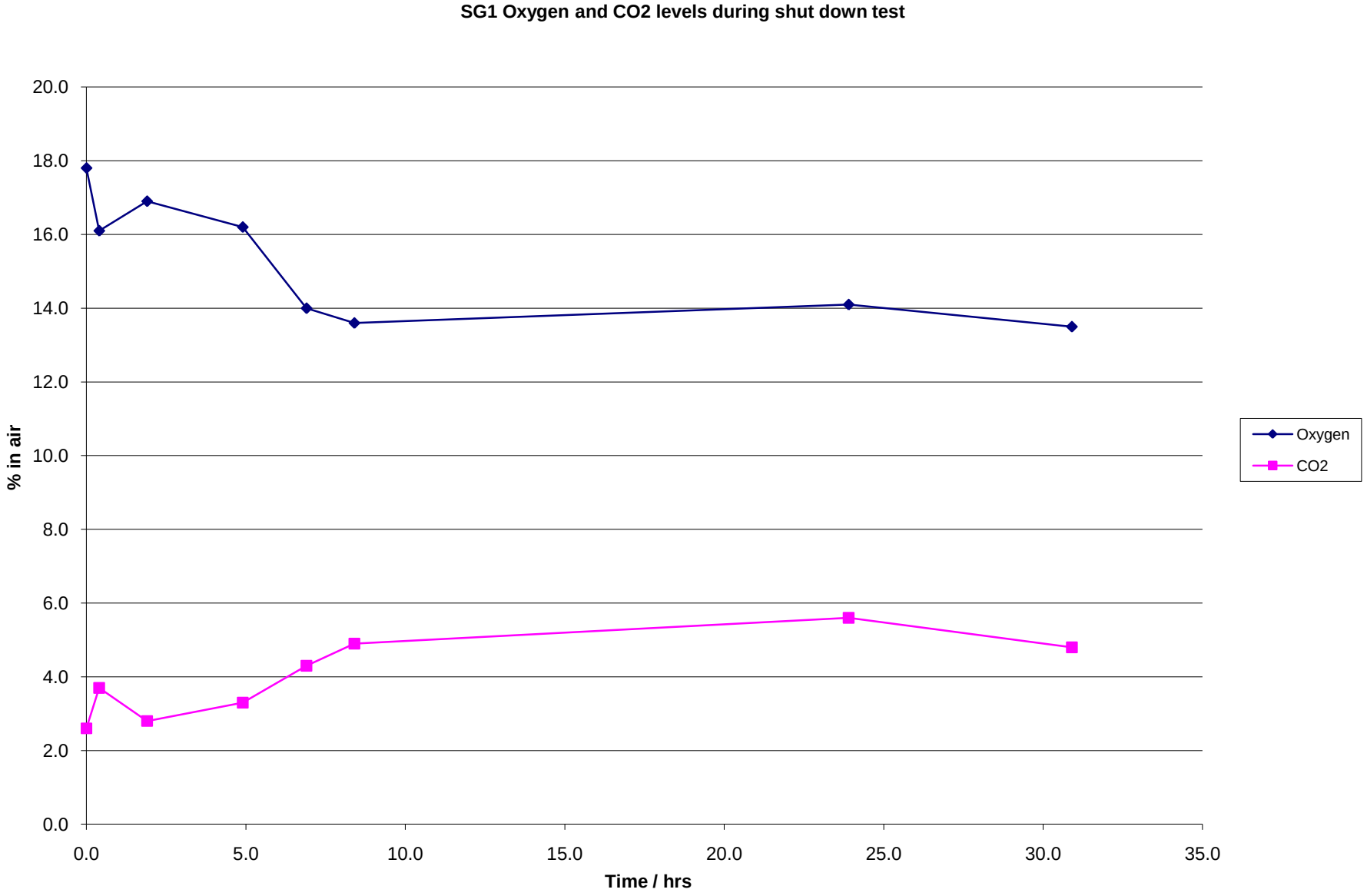
Table 2

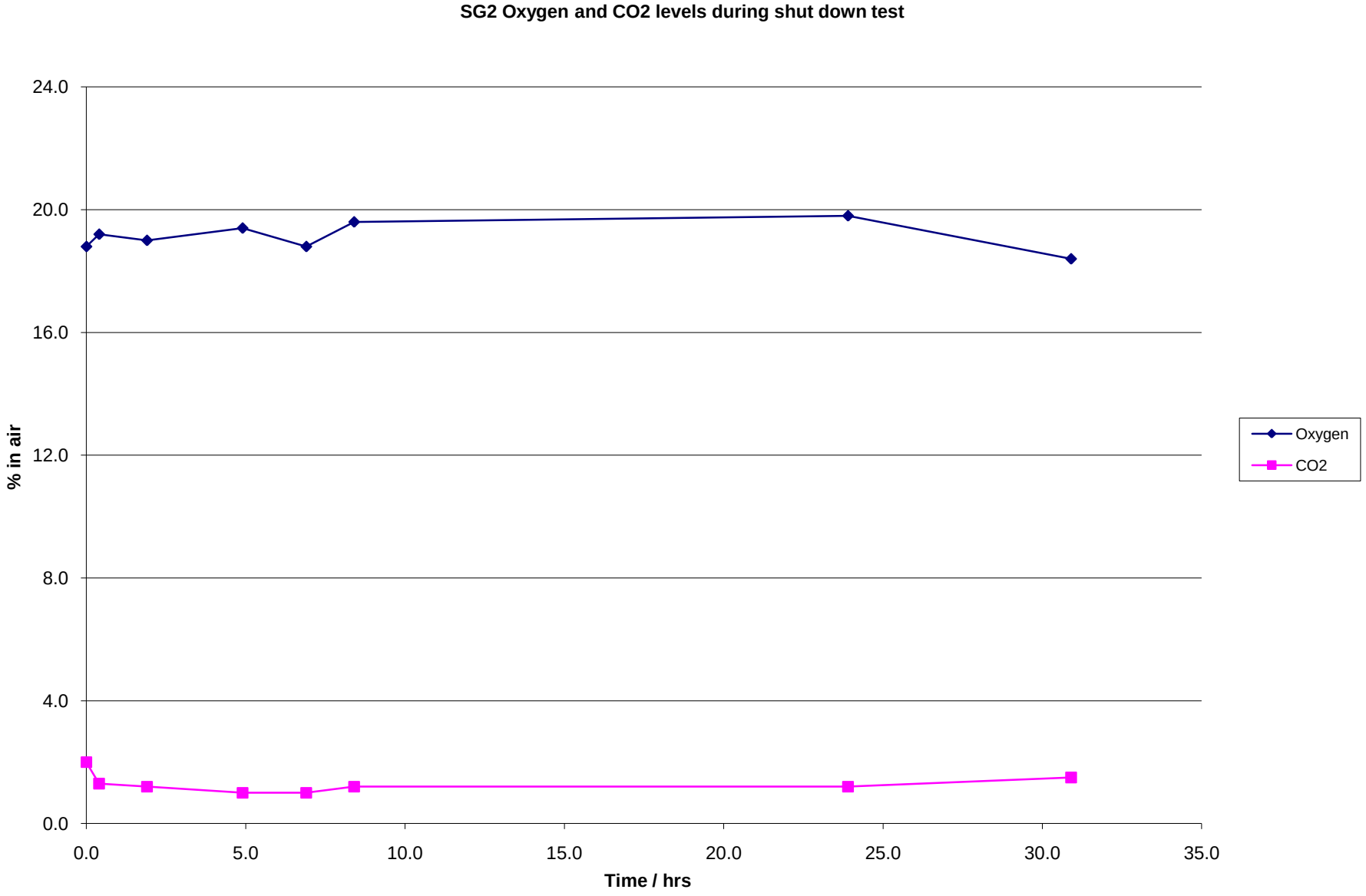
Shutdown Respiration Test
Carbon dioxide Results

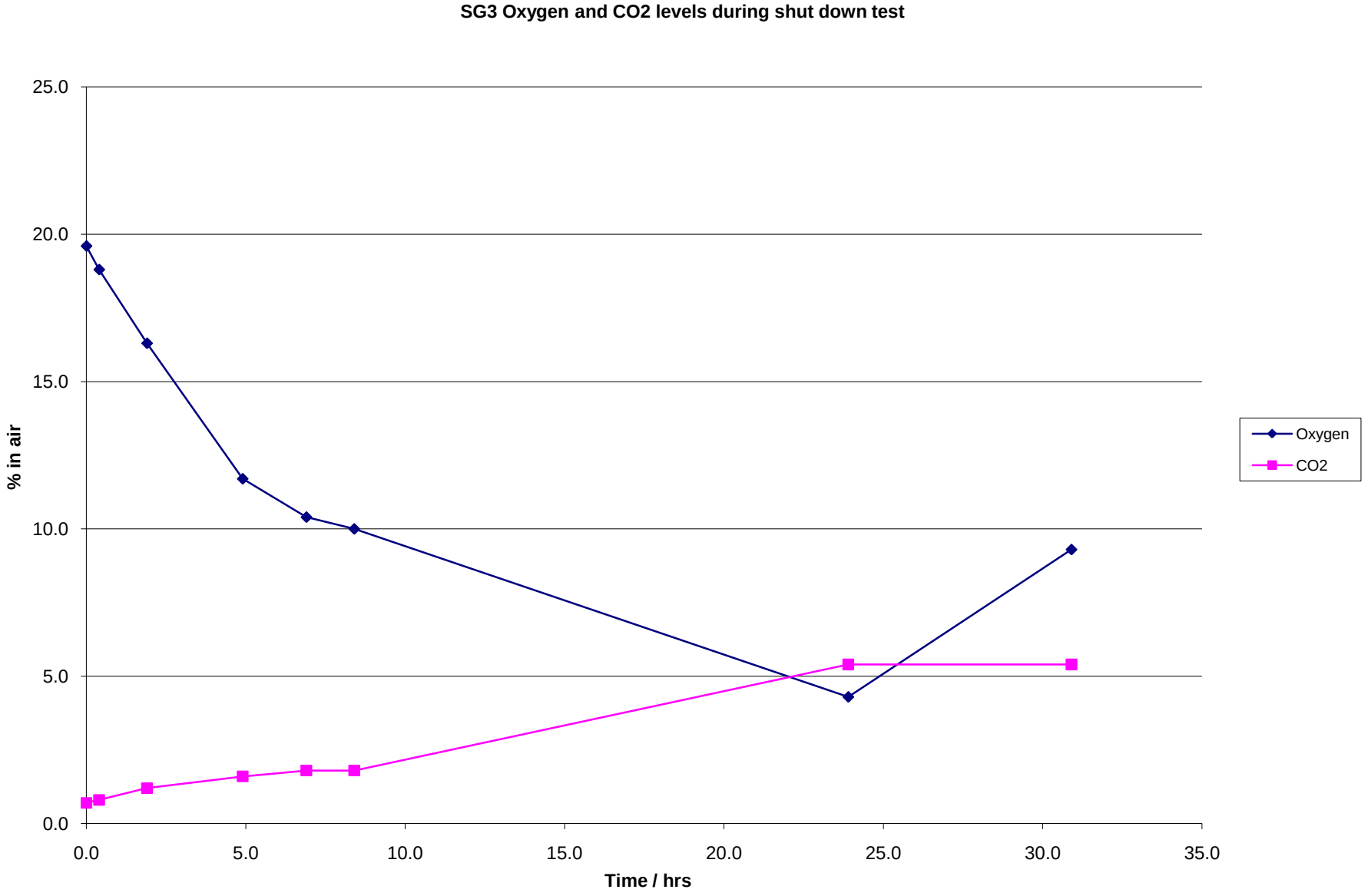
Soil Gas Probe	Baseline (% CO2)	Hour 0.5 (% CO2)	Hour 2 (% CO2)	Hour 5 (% CO2)	Hour 7 (% CO2)	Hour 8 (% CO2)	Hour 24 (% CO2)	Hour 31 (% CO2)
SG-1	2.6	3.7	2.8	3.3	4.3	4.9	5.6	4.8
SG-2	2	1.3	1.2	1	1	1.2	1.2	1.5
SG-3	0.7	0.8	1.2	1.6	1.8	1.8	5.4	5.4
SG-4	13.2	13.7	13.2	12.5	13.5	14.3	17.7	14.2
SG-5	2.7	2.8	3.6	4.8	5.2	5.7	8.6	8.2
SG-6								
SG-7	3.3	3.3	3.5	4.4	4.7	4.9	8.6	7.9
SG-8								
SG-9	14.5	10.2	8.3	8.6	8.6	9	14.3	14
SG-10	2.3	2	3.9	1.2	3.6	3.5	1.4	1.3
SG-11								
SG-12	1.6	2	2.8	4.4	4.5	5	10.5	6.3
AVG	4.8	4.4	4.5	4.6	5.2	5.6	8.1	7.1

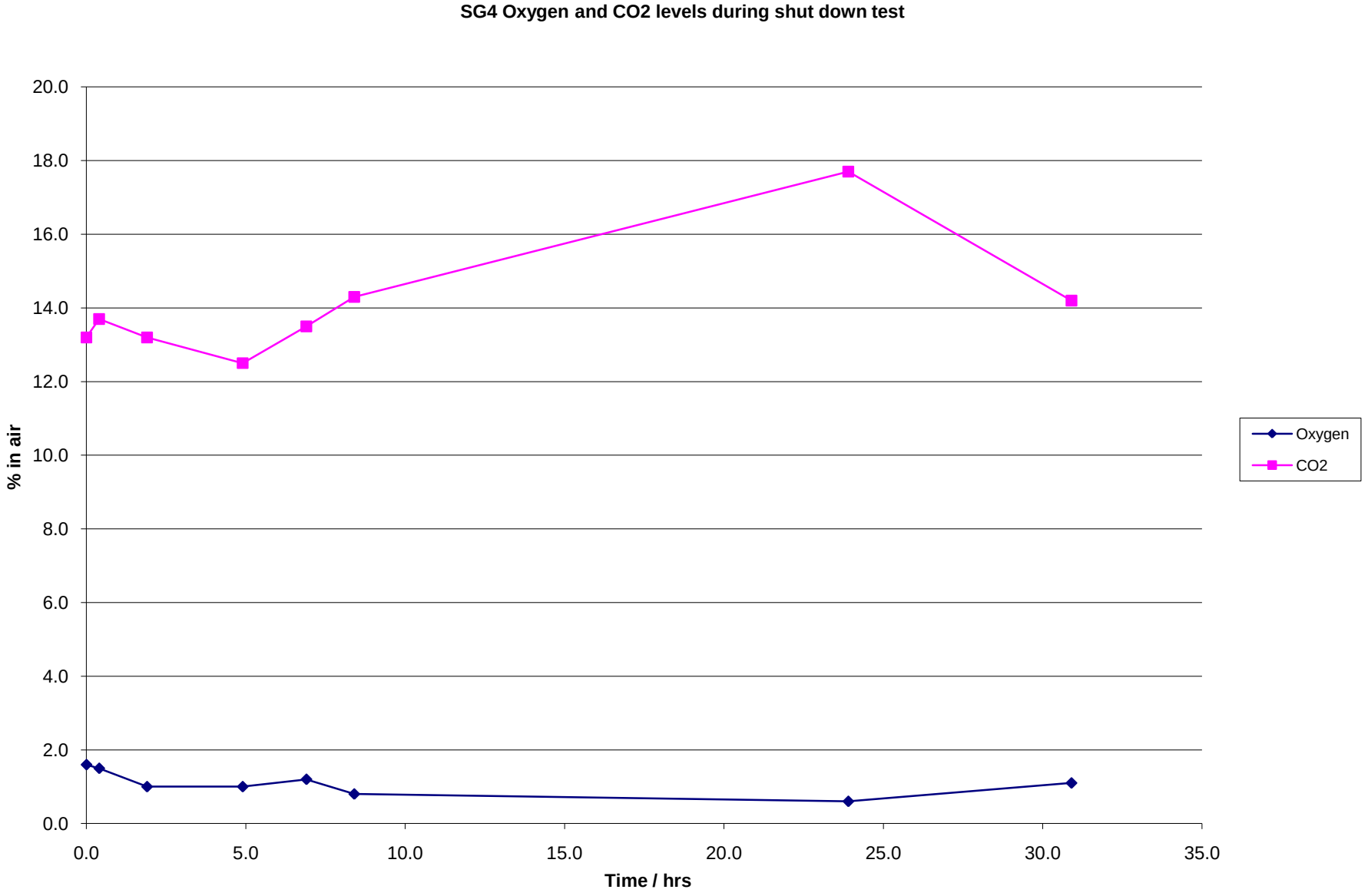
Figure 1 - Average of O_2 and CO_2 Levels

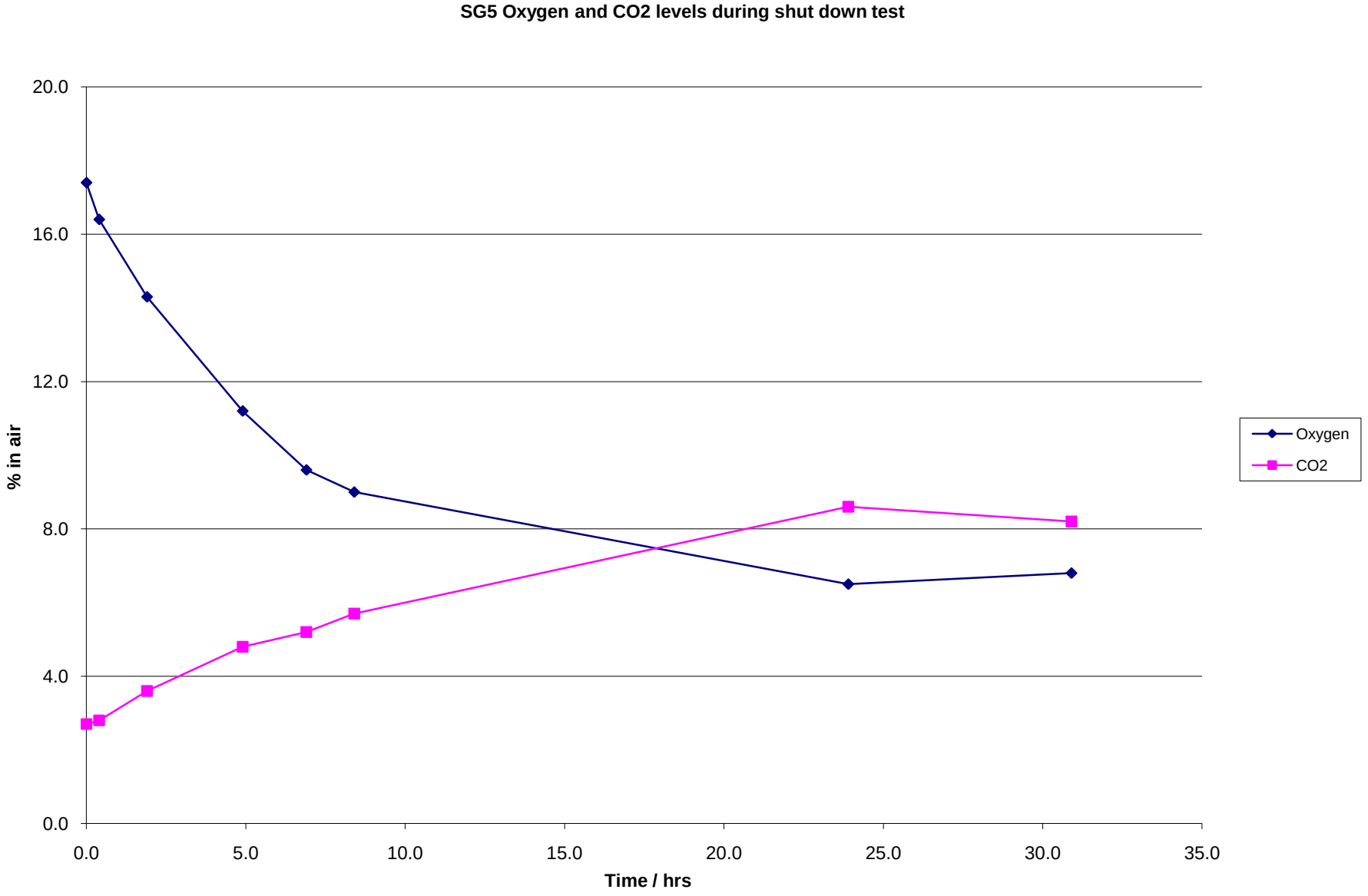


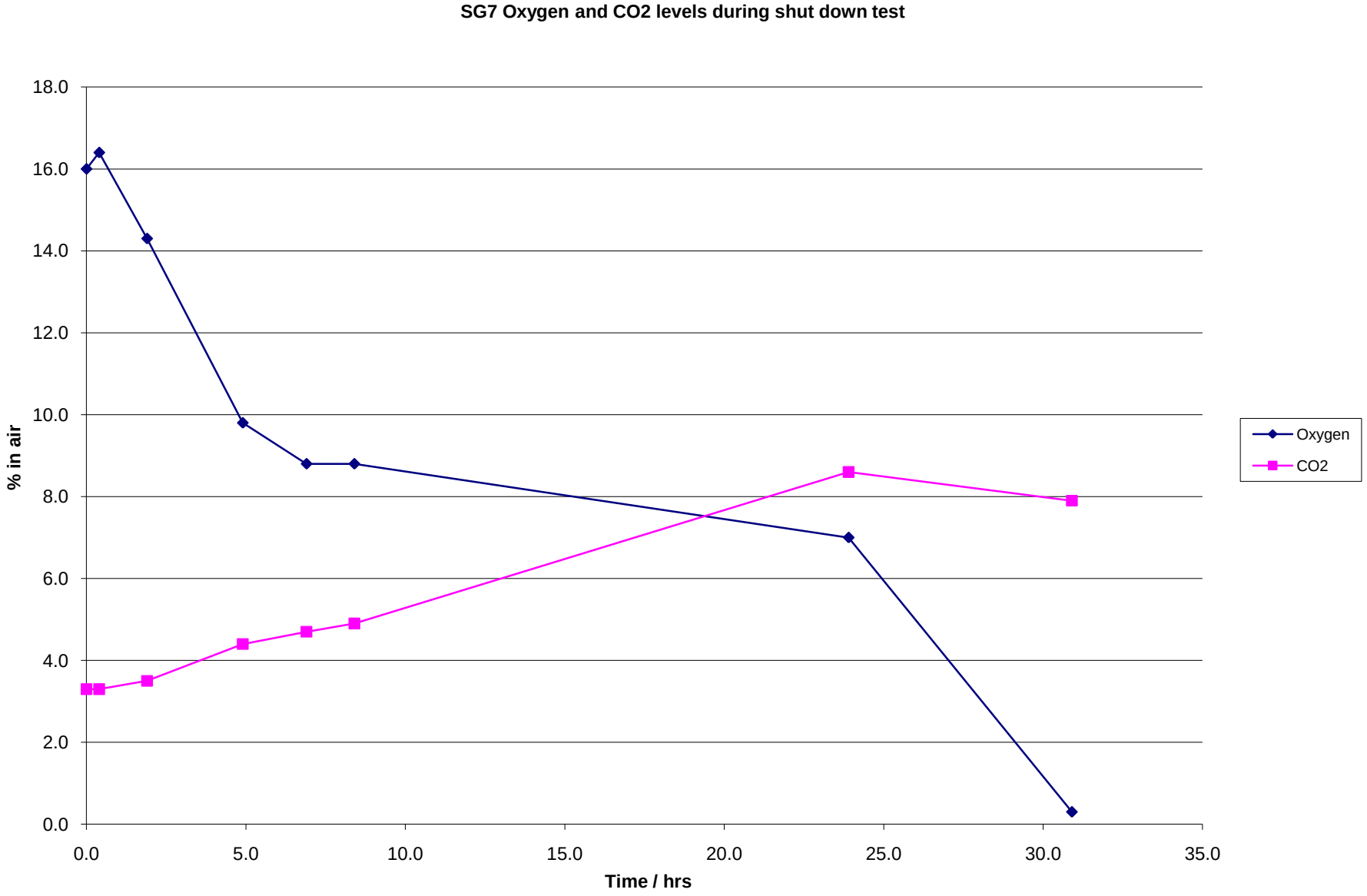

SG1 Oxygen and CO2 levels during shut down test
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
% in air
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Time / hrs
Oxygen
CO2

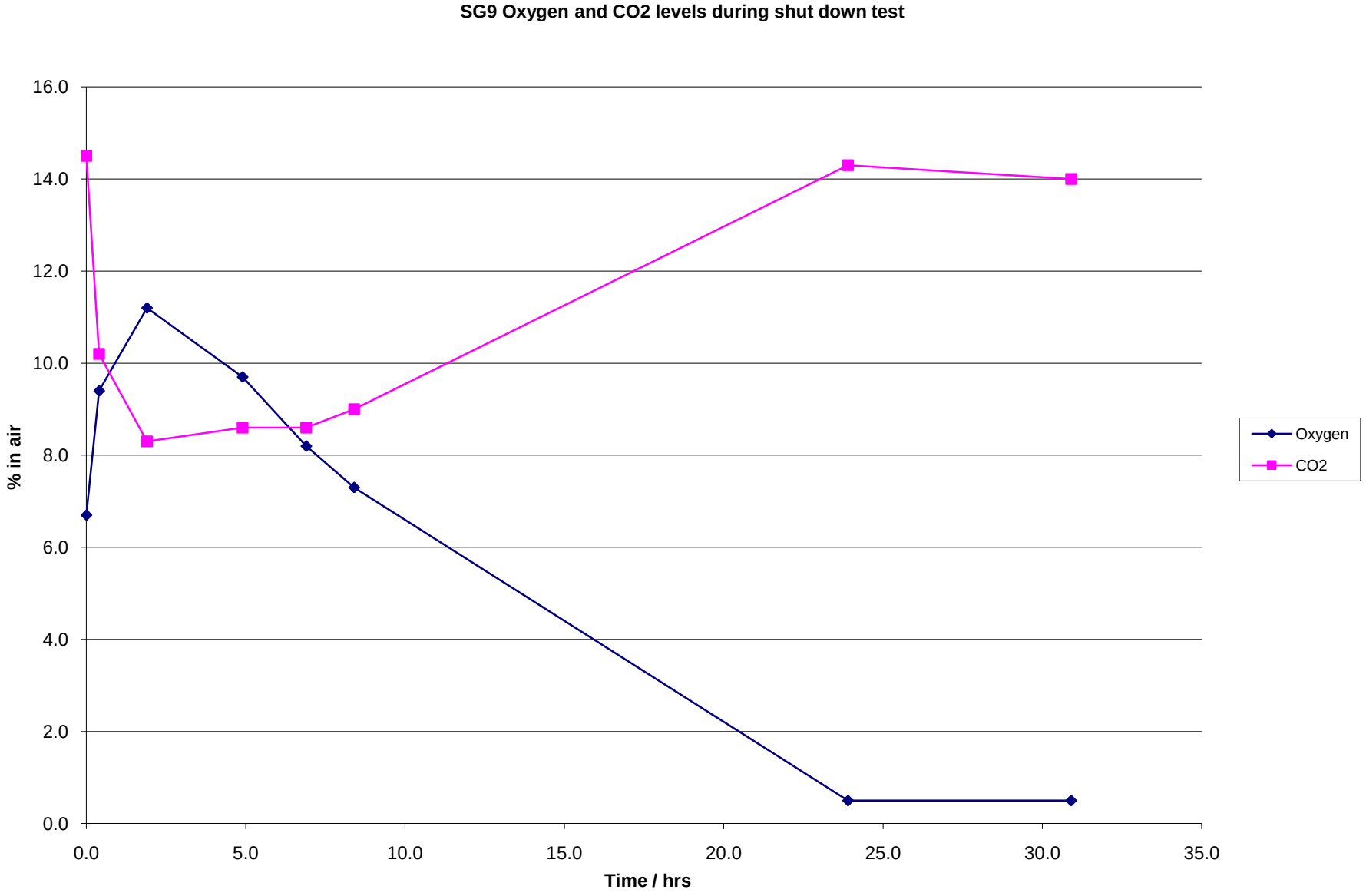

SG2 Oxygen and CO2 levels during shut down test
24.0
20.0
16.0
12.0
8.0
4.0
0.0
% in air
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Time / hrs
Oxygen
CO2

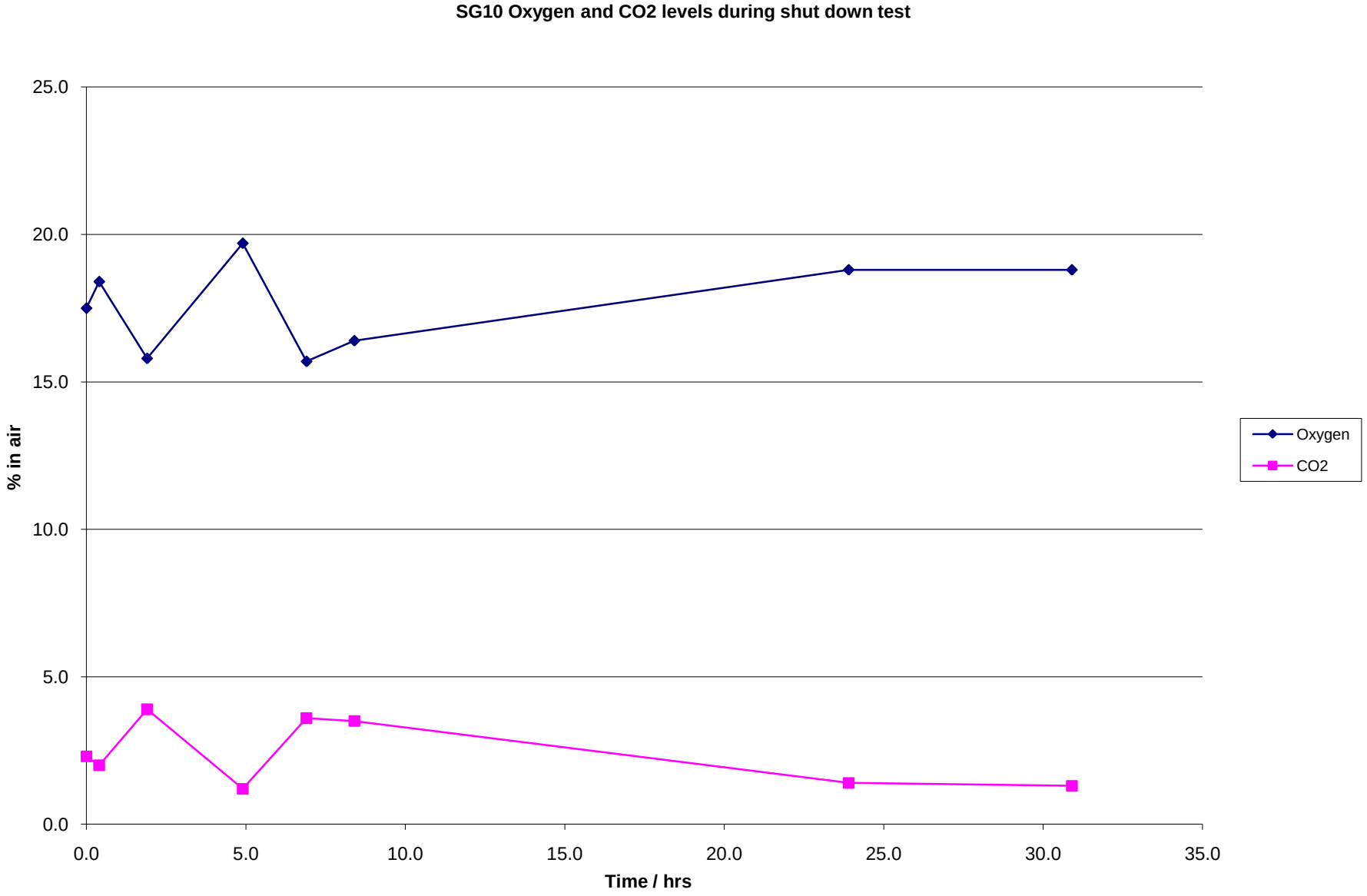

SG3 Oxygen and CO2 levels during shut down test
25.0
20.0
15.0
10.0
5.0
0.0
% in air
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Time / hrs
Oxygen
CO2

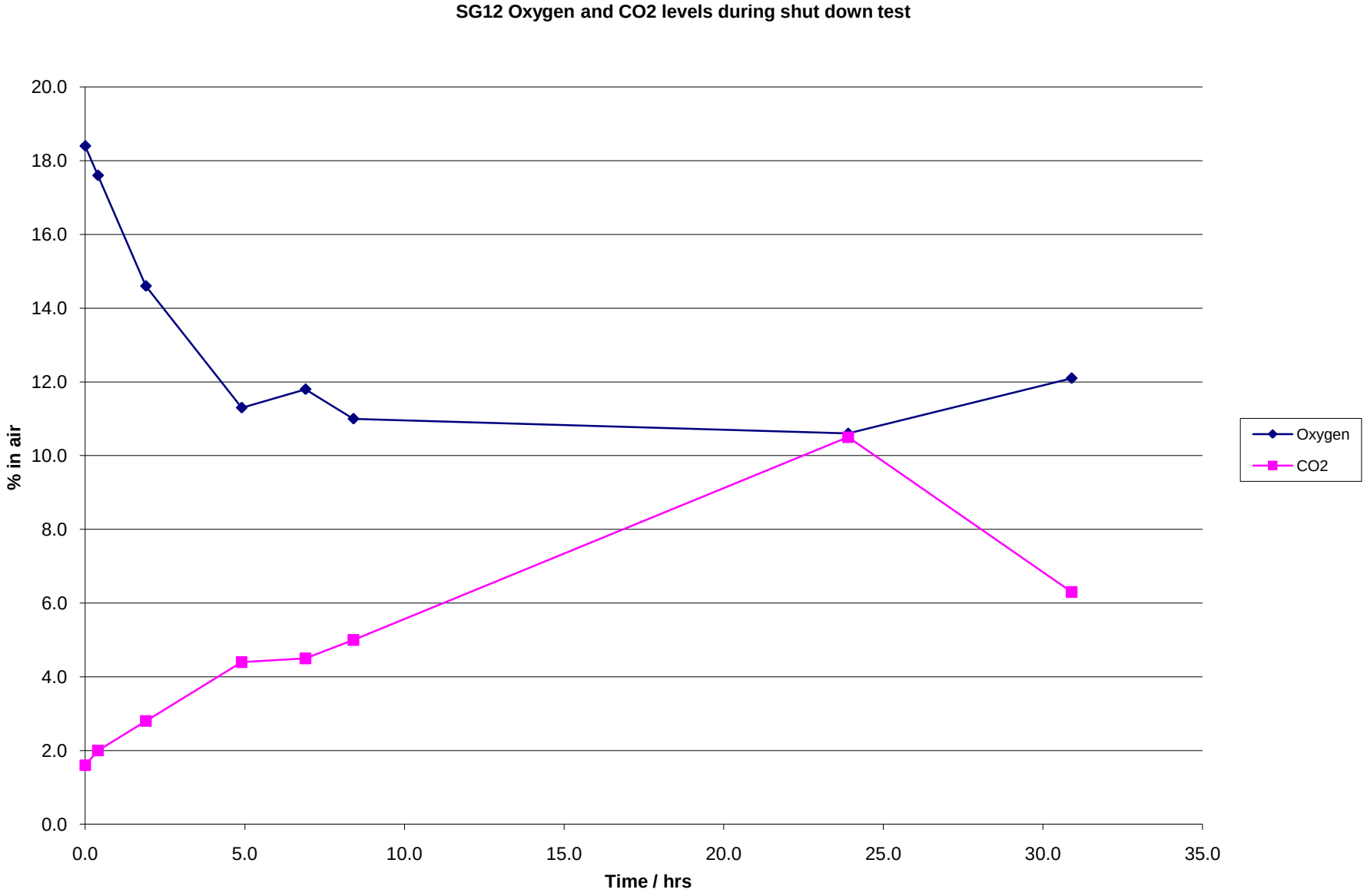

SG4 Oxygen and CO2 levels during shut down test
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
% in air
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Time / hrs
Oxygen
CO2


SG5 Oxygen and CO2 levels during shut down test
20.0
16.0
12.0
8.0
4.0
0.0
% in air
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Time / hrs
Oxygen
CO2


SG7 Oxygen and CO2 levels during shut down test
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
% in air
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Time / hrs
Oxygen
CO2


SG9 Oxygen and CO2 levels during shut down test
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
% in air
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Time / hrs
Oxygen
CO2


SG10 Oxygen and CO2 levels during shut down test
25.0
20.0
15.0
10.0
5.0
0.0
% in air
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Time / hrs
Oxygen
CO2


SG12 Oxygen and CO2 levels during shut down test
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
% in air
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Time / hrs
Oxygen
CO2